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To: Bruce Baller
Aesook Byon-Wagner

From: Hadron Absorber Review Committee,
Dave Eartly
Mike Gerardi
John Grimson
Sacha Kopp
Mark Reichanadter
T.J. Sarlina
Joel Misek - Chair

Subject: Numi Hadron Absorber Review Committee Report

This report summarizes comments generated from the NUMI Hadron Absorber review presentation made on June 12, 2001. The comments are grouped into categories that closely follow the specific issues that were to be considered as stated in the charge to the committee.

1. Radiation Analysis

The MARS model needs to be run with the current design geometry. This geometry needs to address the issue of cracks and must be thought out carefully with consideration given to block tolerances, block lifting voids, and areas such as the roller track, containment pan, and module base.

Resources should be provided to address the outstanding issues as stated in N. Grossman's report. This work needs to be completed in a timely manner and any changes generated incorporated as early as possible into the absorber design. RAW tritium production calculations need to be made for factoring into operational considerations. It is not clear from the limited time allotted for review that all the pertinent dose rate calculations for the labyrinth and penetrations take into account the current design. It is also not clear whether there has been concurrence by the ES&H Section with regards to groundwater protection and the 10' tunnel flow. With respect to airborne activation, it should be stated on how many air exchanges per hour can be achieved.

The "one hour" accident condition needs to be reevaluated in the light of the current target and baffle arrangement as well as from the operational likelihood potential. The presented accident condition appears to be extremely conservative. This directly impacts many design issues in the absorber and other portions of the overall NUMI project. An accident scenario should be developed that is reasonable and which can be justified.

2. Thermal Analyses

Both transient and steady-state thermal analyses were performed on the Hadron Absorber. The results appear consistent (within ~25%) and credible. The maximum absorber temperature (#4 module receives the maximum energy deposition) is 368 degrees C ~steady state after 1800 pulses. The thermal analyses (B. Wands) assume a 50 gpm flow rate through each water circuit (2 circuits/module), which is not consistent with the RAW skid capability (70-80 gpm). This inconsistency needs to be resolved. The mechanical stress due to the significant energy absorbed over the 10 micro second beam pulse was also investigated, with the resulting stresses determined to be acceptable.

The possibility of cooling a module with conduction, convection, or radiation to an adjacent module or to the base plate in the event of a total loss of water cooling to a given module should be considered. The "one hour" accident heating model was used which, as stated previously, is not based upon any plausible scenario. With a revised accident scenario, the possibility of adequate cooling during the accident may be handled by air flow alone. Remote valving of each module circuit at the manifolds is endorsed.

3. Core Design & Repair/Replacement

With the high radiation levels present in the absorber, the current design does not allow for module replacement. A specific procedure for replacing a module was not presented. ALARA principles, which would be part of this module replacement, were therefore not included in this discussion. Secondary containment in the absorber was only briefly discussed. No discussion explained what happens with the contained fluid or how one might retrieve the fluid for proper radiological disposal. Long term reliability was not defined other than stating that it would be a minimum 10 years.

The question of decommissioning does not appear to be unduly compromised by the absorber design, however remote handling will be difficult given the lack of a permanent crane. With the proper rigging equipment and shielded coffins, the absorber could be disassembled although at a high cost relative to its installation and a significant absorbed dose to the decommissioning crew.

The critical welding of the module cooling tubes needs to be modeled for quality control. The space constraint puts heavy responsibility on the individual welder's skills. Automatic welding may be a possible option for the tight space welds. The QC requirements of the welds need to be defined, be it x-ray, ultrasonic, die penetrant, hydrostatic testing, etc. Also to avoid stressing of welds from relative displacements (modules, manifolds, supports), thermal effects, pump and manifold vibrations, module water lines must be supported in a compliant way with some expansion-displacement capability at the manifold connections (e.g., braid covered metal bellows hose connections or expansion loops).

On a more global note, the reduced scope of the project resulted in changes to the Absorber Cavern geometry that will have an impact on the design and operation of the experimental apparatus. These impacts need to be fully understood and incorporated into the equipment design. For instance, the loss of the overhead crane and the radiation worker exposure regulations have, in effect, combined to remove the possibility of module replacement during the planned life of the experiment. A less complex design of the core modules, cooling connections, and support systems may present an opportunity for cost savings and an increase in reliability. Examples might include elimination of the Tube Guides, elimination of the Core Assembly/Removal Stand, higher reliability for cooling water connections due to better access for the welder, less costly quality assurance checks for finished cooling water welds, etc.

4. Installation Plan

The installation plan relies on specialized equipment modified to deal with the absorber's unique layout within the enclosure. Given this need, availability on renting and modifying this equipment at a specific time may be problematical or costly. Investigation into rental with the option to buy may be a possibility. The extent of modification may make purchasing of the units a more cost effective option. As presented, the twin lift used to move the shielding blocks within the enclosure is diesel powered. The cost of additional enclosure ventilation required by the use of diesel power was not presented. With this in mind, the availability of battery powered equipment should be investigated. If owned by Fermilab, the twin lift might be able to be converted to battery, electric or hydraulic power.

There were some inconsistencies in the time estimates with the block placement time not agreeing with the block lowering time into the enclosure. These installation time estimates need some refining but generally appear reasonable for the plan as presented.

A few additional observations need to be highlighted. There did not appear to be a plan for staggering the steel and concrete blocks during installation to eliminate continuous cracks. There does not appear to have been any consideration given to stress on the welded water connections from floor loading once the shielding is added after the welds have been completed. The twinlift has a moveable counterweight (i.e. 5 ft). This along with the 10' turning radius in a very confined area may require a second operator (called an oiler) to be used as extra eyes. It is unclear if this was included in the cost analysis. The fail-safe operation of the twin lift on a slope with load when it looses power was not discussed. Since two of crew may be on foot and within confines of the tunnel and no where to go if the lift becomes a runaway. The twin trolleys on the gantry beam if it is not level might also become dangerous to the crew when setting blocks or the absorber. The trolley drive should have fail safe brakes. If the trolley is used with slings or chain, a safety restraint should keep high inertia loads from swinging and pinning anyone against the cavern enclosure or other blocks.

5. Cost Estimate

Since the design is still undergoing development, this cost estimate can only be considered a ballpark figure. It will need to be refined as the specifics of the installation are finalized and the schedule developed.

Careful coordination of rigging crews will be necessary. The multiple 3 man crew teams overall output will be driven by the slowest crew. This makes for the possibility of significant dead time for this rigging activity. The possibility of cost creep with such a large installation window will make accurate cost estimation of rigging work difficult.

The engineering time estimate for the absorber does not include oversight for the assembly and installation of the various mechanical components. Depending on the extent of changes on the design, the engineering and drafting estimates may need to be increased.

In a more general sense, what appears to be called for is a fully-integrated resource loaded cost and schedule estimate. This would have helped provide a compete picture of the Hadron Absorber, insure that all costs are captured, the schedule is coherent, and the available contingency is adequate. An integrated cost and schedule apparently exists, but unfortunately was not presented to the committee. Presenting this to the committee would have been extremely helpful in assessing the credibility of the Hadron Absorber cost and schedule planning.

6. Instrumentation and Beam Interlocks

The instrumentation and beam interlocks presented in the RAW system document and the NUMI Beam Permit System document appears to be reasonably complete. Modules must include redundant thermocouples for temperature monitoring, and both flow rate and system level will need to be interlocked.

Attention should be paid to errant pulse detection. The target and baffle should either be physically locked into position or interlocked in the correct configuration to avoid excessive beam loss.

Additional comments:

It should be understood that the design of the absorber leaves little room for future upgrades in intensity. The radiological assumptions are based on past designs. Current calculations are needed to predict dose rates and activation levels so that the systems can be confidently designed. Without updated source terms, the operating intensities could be in jeopardy.

Personnel egress could be a worrisome issue and needs to be reevaluated as absorber design changes. The nearest egress is 660’ downstream. Upstream appears ~twice that distance. There was no discussion of O^2 monitors in this confined space, how to evacuate quickly if someone is injured, or what to do in the case of fire—a fire blocking the downstream end might be particularly hazardous, since the fumes would drift upstream and the path to good air is longer.

Concluding Remarks:

This review has looked at the NUMI hadron absorber design as it presently exists. Though the design is still ongoing and many specific elements require further work, no insurmountable problems appear to exist.

The absorber must be developed with the highest reliability possible. Absorber design changes based on the present beamline and cavern should be investigated as expeditiously as possible.

The unique installation environment for the hadron absorber is a design challenge. The deletion of the permanent overhead crane and the down sizing of the enclosure require a unique installation scenerio. This scenario is workable though the cost and oversight may be higher than for a more conventional layout.

The resources presently allocated for the hadron absorber will need to be continued as the final design is developed.